Water and Timber Management

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The water produced by forest land increases in importance as our water needs grow because the bulk of our high water yielding areas are forested. With an understanding of the relative values involved and good management, water and timber production are compatible. Too often, timber harvesting causes erosion which reduces the quality of water although logging can and should be done as to avoid damage to the water crop. There are methods for increasing water yields without risking flash floods or water quality but this is possible only on watersheds with good soil conditions. Much of our forest land has been damaged by past agricultural use, grazing, fire and careless logging. The first watershed need on these areas is improvement of infiltration and water storage capacity. The forester should rcognize the need and the opportunity for better watershed management.

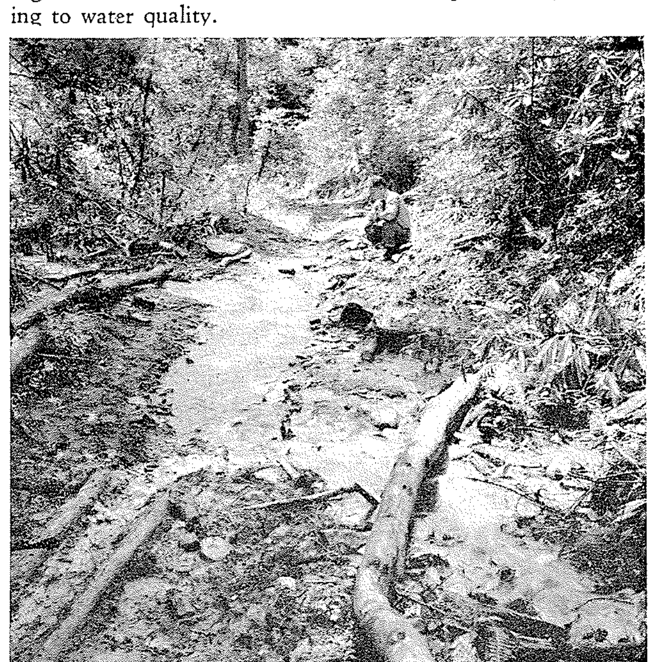
WATER IS ONE of the most valuable products of the land. Just how important the water resource is has been well shown by the experiences of New York and many other cities in recent years. Forecasts for the future indicate that we will have an increasing appreciation of water. Industrial water requirements grow constantly. In the period 1939 to 1949 industrial water use increased 36 per cent. Even in humid regions, farmers are turning to irrigation to increase their crop yield, and in our homes we continually step up water uses. Along with increasing use of water, our people are concentrating more and more into urban areas creating greater pressure upon municipal water sources. Concern for water is not felt only in Los Angeles or New York. It is just as real in almost all parts of the United States; even the Carolinas and Virginia have been wishing for more water in recent years.

The forester has always assumed a professional interest in water, and much of the popular support for forestry in this country has been associated with concern for safeguarding water sources. However, as timber values increased and timber forestry began to pay off for cold cash in hand, foresters became less concerned with the so-called intangible values of forestry activities. This was understandable enough, but now it is apparent that water values are not intangible and that we must take them into account when planning forest practices.

Quality of Water and Need Important

Before we consider what the forester can do about water supplies, we must consider what water users need. In simplest terms, the water must be of a quality suitable for the intended purpose and must be available as needed. By quality is meant the physical, chemical and bacteriological properties. Physical properties include turbidity, temperature and sediment content. Chemical properties are determined by the elements dissolved in the water, while the kind and abundance of living organisms determine the bacteriological properties. It is possible to modify the quality of water by treatment, and most water that we use has been treated. This treatment costs money and becomes more difficult and costly as water quality decreases. In the Southeast, the chemical properties of water are good, and cause little concern. Surface water for human consumption is sterilized by chlorination. Reduction of turbidity is a major treatment needed for Piedmont streams before they can be used. This is accomplished by settling basins, chemical flocculation and filtration. Many towns and cities in and near the mountains have water sources clear enough so that filtering is not necessary, and chlorination and chemical amendment are the only treatment required. Such

Figure 1. Skid roads that cross streams are particularly damaging to water quality.



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From 1940 to 1948, Mr. Hoover was in charge of the Coweeta Experimental Forest carrying out research in the relations between forest cover and streamflow. Since 1948 engaged in working out methods for soil improvement to better tree growing and watershed conditions on abandoned agricultural soils of the Piedmont region.

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municipalities are particularly vulnerable to disturbances on the watershed which would increase turbidity. However, increases in turbidity are disturbing even if a filter plant is in operation. Settling times are increased in detention basins, more chemical flocculants are needed, and filters must be cleaned more often. All of this lowers output and raises costs. For a city using seven million gallons per day, a gain in turbidity might up treatment cost 1c per 1000 gallons or $70 per day for an annual increased cost of $25,550 per year. From generations of observation as well as actual measurements, we know that water from an undisturbed or well managed forest watershed is of excellent quality and superior to that from other types of land use.

The amount of water available for use depends upon the total volume of stream flow and the seasonal distribution of flows. Unless reservoir storage is developed, the lower-water flow sets a limit upon use. Good forest land, because of its excellent characteristics for water absorption and storage, tends to reduce peak runoff rates and prolong the runoff period. However, total yields may be diminished because the water stored in the soil is subject to transpiration.

Vegetation Influences Movement of Water

The forester is in effect managing a huge detention reservoir. The amount of water which enters and leaves the soil reservoir is influenced by the way he manages the vegetation. Dense stands will increase interception losses and transpiration use of water, while thin stands will have less interception and transpiration but greater evaporation. It is necessary to distinguish between evaporation and transpiration because evaporation removes moisture mainly from the surface soil, while transpiration withdraws water uniformly from the entire root zone of plants. Differences in rooting habits of plants are important in determining the water used in transpiration. On the Piedmont of South Carolina, for instance, pine trees take water to a depth of six feet, while broom sedge, with more shallow roots, draws only to a depth of three feet. The more water available to tree roots, the more they will transpire. The fact that has been hard to understand is that forest vegetation creates favorable soil conditions for water storage but at the same time uses and intercepts large quantities of water itself. Because of this, it seems that a watershed manager is faced with problems that have opposing solutions. What is good for flood control appears to be detrimental to water yield.

Actually there is less conflict than is at first apparent. A fundamental objective of watershed management is to prevent overland flow of water. Any kind of practice that reduces the capacity of the soil to take in water will cause trouble without compensating benefits. Flash flood flows and muddy streams do not occur from ground water and seepage flow through the soil mantle. Methods for increasing water yields by reducing density or changing cover types are practical only on watersheds with good soil conditions. Most of our forest land in the Southeast has been subjected to careless logging, grazing, fire and past agricultural use. The first watershed need on these areas is management to improve infiltration and moisture storage within the soil.

Where favorable soil conditions are present, we can manage vegetation to increase water yields. This has been well demonstrated by pilot studies at the Coweeta Experimental Forest in Western North Carolina. On two 40-acre watersheds which had an oak-hickory forest, stream flow was measured for a five-year standardization period. The trees were then cut, but to prevent soil disturbance were left where they fell, the tops lopped, and the branches scattered to form a mulch for soil protection. The first year after cutting, stream flow was increased 65 per cent. (The increased water yield was equivalent to a depth of 17 inches over the surface of the watershed.) Stream flow during the normal low-water period of summer and fall was 100 per cent greater than before treatment. On one watershed, regrowth has been kept to a minimum by annual mowings of vegetation, and the same proportional increased runoff has been maintained. Because all runoff is derived from seepage and ground water, flood peaks have been no larger than before cutting. On the second watershed, natural regrowth was allowed, and stream flow has gradually decreased. However, eight years after the clear cut the water yield is still 20 per cent greater than before treatment. Water yields are greater because, with the reduction in transpiration, summer rainfall was sufficient to raise the soil above field capacity so that free water could pass through the soil, recharging the water tables which feed the streams.

Stream Flow Increased by Removing Trees

Experiments at Coweeta and other parts of the country show that trees and other plants growing along streams and in areas where water tables are high use exorbitant amounts of water because they have access to almost unlimited supplies. It is possible to increase low-water stream flow by removing these trees. At Coweeta, cutting all streambank trees within 15 vertical feet of the stream channel increased summer stream flow 20 per cent, even though the area cut over was only 12 per cent of the watershed. Before the streambank vegetation was cut, water levels had been gradually lowered each sunny summer day by transpiration draft, but during the night they built back again. This diurnal fluctuation was eliminated when trees "with their feet in the water" were removed.

These experiments and others clearly indicate that man has the power to change the amount of stream flow by controlling vegetation. Such drastic treatments may find application on certain municipal watersheds where increased yields are necessary and there are no other sources of supply. For more typical situations we will have to develop methods which are more compatible with other uses of forest land. As we achieve greater understanding of the processes involved, it appears reasonable that we can achieve some improvement to water yields and produce timber too. On some forested watersheds, it is likely that we will strive to keep the minimum cover that will protect the soil in valley bottoms and other places where the water table is within reach of roots but practice timber forestry on the slopes. As in all cases of multiple use, compromises must be made which balance the values involved. It will not be necessary that management for water production will always limit timber production. For example, at Coweeta it has been possible to increase stream flow by elimination of a dense rhododendron and laurel understory, and this assists not only water yield but also tree growth.

Logging Operations Create Soil Disturbances

It has been shown that reduction of tree cover is not detrimental to water supply as long as forest soil conditions are maintained. Unfortunately, in most of our timber harvesting we foresters have not fulfilled this later condition. Most logging operations create considerable soil disturbance, particularly because of the truck roads and skidding trails. Large quantities of dirt may be dumped directly into streams, unstable cuts and fills are made, and areas of impervious surface are created. A small amount of such disturbance is sufficient to muddy the flow of even a good sized stream. This is well shown by a study at Coweeta where a 200-acre watershed was logged by teams and trucks as commonly used in the Southern Appalachians. A total of 2.3 miles of truck road was bulldozed into the watershed to finish the logging job. Turbidity of the water from the logged area averaged 93 parts per million as compared with four p.p.m. for the stream on an adjacent undisturbed area. During storms, the water turbidity on the logged area reached a maximum of 7000 p.p.m. as compared with 80 p.p.m. for the check area. Repeated measurements of road cross sections showed that in four years the 2.3 miles of road lost 6,850 cubic yards of soil. From these figures, it is easy to see why this one logging job was sufficient to muddy the water from the 4000-acre watershed to which it is only a minor tributary. Flash runoff from the roads has also doubled flood peaks. Although the logged area is still forest covered and will produce another crop of timber, its water quality and sediment production are more typical of hillside cornfields than of forest.

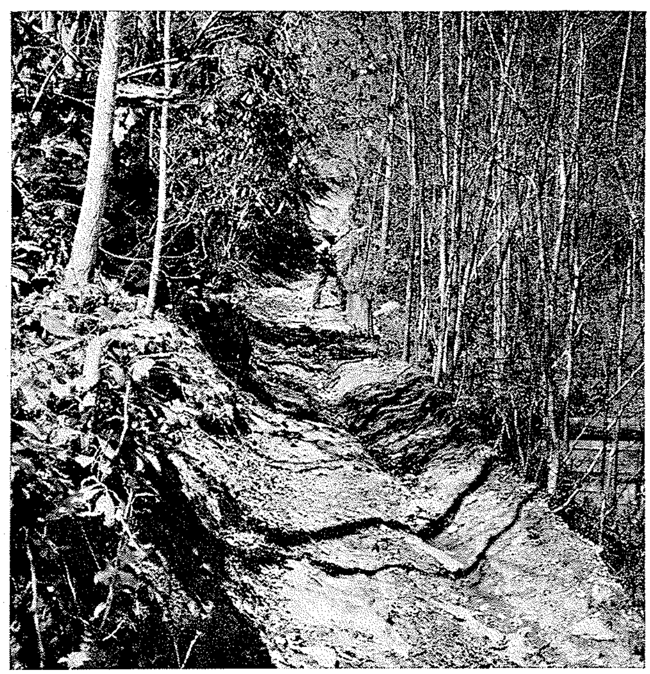

Figure 2. Coweeta logged-area skid road 2 years after last use.

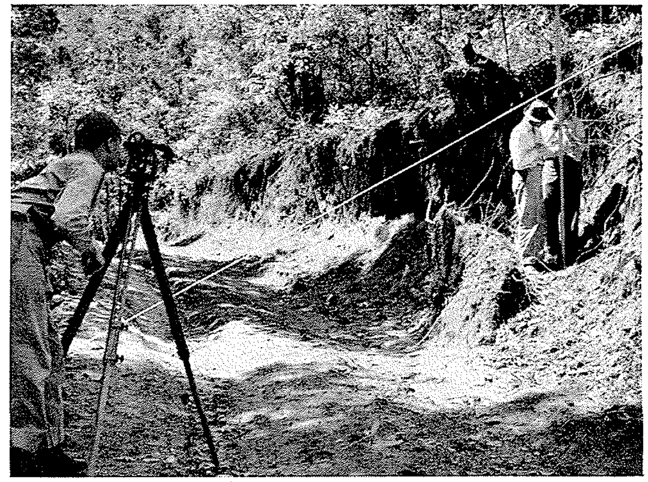

Figure 3. Measuring soil loss from the logging road.

Fortunately, there is little mystery about the principles of erosion control and there are examples of good logging jobs which have caused no trouble. The first step in preventing damage is to realize that muddy water can cause downstream damage and make the water unusable for municipal and industrial consumers unless a filter plant is constructed. Muddy water increases the cost in any case. Much of the transported sediment will eventually be deposited in a reservoir, limiting the value of expensive water storage projects. Muddy water also

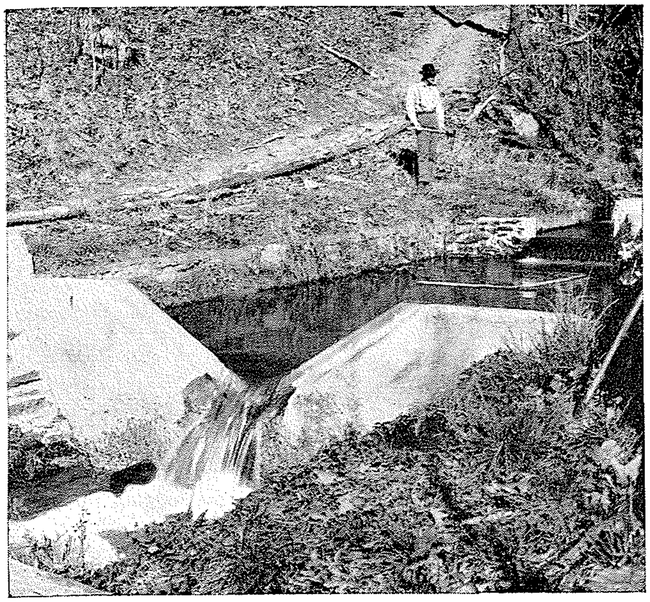

Figure 4. Weir that measures stream flow from the logged watershed.

harms aquatic life and is ruinous to trout, as well as to other recreational values.

Road and Trail Locations Must Fit Areas

A number of commonsense improvements will go a long way toward lessening damage to water quality. The logging methods used should be suitable to the terrain. For example, in steep country, cable logging systems frequently expose less soil than does truck and tractor logging with its dense network of roads and trails which funnel together creating even greater concentration of water. Road and trail location should receive more attention to avoid steep grades and unstable areas. The road system should be designed to fit the area and the products to be obtained. Too often a low standard road is punched in to reach a particular stand of timber without much thought to possible later use. Or one operator will build a road to get out the saw timber and will be followed by a pulpwood operator who may find the first road unsuitable and then build more road. This lack of system results in more road construction than is actually required to harvest all products. Experiences of this sort show that the location of all forest products in the area, together with a procurement and management plan, should be known ahead of time so that the road layout can be more efficient as well as less damaging to the water resource. The possibility of amortizing the cost of a better road over a period of time rather than paying for a poor road from a single operation should be considered.

The matter of road drainage can hardly be overemphasized. Because roads are usually unsurfaced, the ever-present wheel ruts nullify the use of crowning or sloping the road for drainage. This means that built-in drainage by grade breaks, turnouts, water bars, or open top culverts is almost invariably necessary to prevent erosive concentration of water, and such features must be maintained in operating condition. Most of the preventable erosion from logging occurs during the life of the operation and it is impossible to make up for lack of maintenance if it has been too long deferred, because, by the time repairs can be made, the eroded soil has already been deposited in the creeks. It is customary to consider slides and washouts as being invariably caused by unexpectedly heavy rainfall, when most frequently they are actually due to poor road location, construction and maintenance, with the rain that caused the damage no heavier than usual. As someone has said, "Somehow cloudbursts get to be a lot more common on areas that we log."

On many logging jobs the complications of contracting, sub-contracting, and sub-sub-contracting divide and obscure responsibility. In such a situation no one feels responsible for the preservation of water values. A complete discussion of these considerations is somewhat beyond the scope of this article. In almost all cases, however, the economic problems resolve themselves into one of possible increased initial capital investment versus much higher maintenance costs. Experience has shown that a properly planned and operated logging job, while it may require higher initial outlay of capital, lowers maintenance cost and increases efficiency and profits in the long run.

Obviously, other common forest practices beside log skidding and hauling can also affect water supplies, although few will cause such immediately spectacular changes as does carless logging in a region of intense rainfall and erosive soils. Silvicultural practices by control of stand density and species composition can influence interception, the amount of water transpired and evaporated, as well as soil properties which control infiltration and moisture movement and storage within the soil. Consideration was given earlier to some effects of changes in stand density and species composition upon water available for stream flow. It is important that we learn more about handling vegetation to increase water yields, but it is even more important that we learn how to manage vegetation to improve infiltration and moisture shortage within the soil. The bulk of our present-day forest land has been subjected to fire, grazing, and careless cutting practices. Much of it is abandoned crop land. As a result of past abuse the soil seldom possesses its original capacity for moisture storage and absorption. Improvement of this condition is the first objective of management for water control.

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